

MULTIMEDIA



UNIVERSITY

STUDENT ID NO

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MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 3, 2022/2023

EEL 3136 – ELECTRICAL DRIVES

(LE)

04 OCTOBER 2023

9:00 AM to 11:00 AM

(2 Hours)

INSTRUCTIONS TO STUDENT

1. This Question paper consists of 9 pages including cover page with 4 Questions only.
2. Answer ALL questions. All questions carry equal marks and the distributions of the marks for each question is given.
3. Please print all your answers in the Answer Booklet provided.

Question 1

A separately excited DC motor is used for a rolling mill. It compresses metal into a uniform thickness, bend it into custom shapes, and create custom-sized stripping. The load is constant and its value is 230 Nm. Maximum speed of the machine is 2500 rpm and it rotates clockwise only.

- a) Select motor and drives for the machine (refer to Tables Q1a and Q1b). [6 marks]
- b) Sketch wiring diagram for the dc drives and motor, from 3 phase AC supply, 400V, 50Hz until the connection to Armature and Field terminals of the motor. [4 marks]
- c) Calculate the firing angle required at DC drives to run the motor at 1800 rpm and at $\frac{3}{4}$ load. [8 marks]
- d) Explain four quadrant operation of typical motor and state in which quadrant the rolling mill motor operates. (Explain with help of the Four-Quadrant chart) [7 marks]

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Table Q1a: DC Motor Selection Motor

400 Nm**180-4A**

Technical data

	n_{max} 4500 min ⁻¹	n_0 40 min ⁻¹	J 0.39 kgm ²	P_r 1520 W	U_{armax} 550 V	U_r 110-440 V	V_{cool} 1300 m ³ /h	P_r 1250 Pa	W_{cool} 290 kg	$W_{maxcool}$ 320 kg			
Cat. Nr	U_r (V): 400	420	440	470	520	550	P	i	T	η	n_r	R_a (115°C)	L_a (0Hz)
FR 159...	n_r (min ⁻¹)						(kW)	(A)	(Nm)	(%)	min ⁻¹	(Ω)	(mH)
101-RC	650	700	730	780	900	950	27	85	400	77.9	2300	0.73	15.7
							29	85	400	78.9			
							31	85	400	79.7			
							33	85	400	80.8			
							37	84	394	82.5			
101-PC	750	800	840	900	1020	1090	39	83	389	83.4	1500	0.63	12.4
							32	97	406	80.2			
							34	97	406	81.0			
							36	97	406	81.7			
							39	97	406	82.7			
							43	95	399	84.2			
							45	94	395	85.0			
101-NC	880	930	980	1060	1190	1280	37	111	407	82.4	2730	0.47	9.5
							40	111	407	83.1			
							42	111	407	83.7			
							45	111	407	84.6			
							50	109	400	85.9			
101-LC	1040	1100	1160	1250	1400	1490	52	108	396	86.6	3740	0.37	7
							43	126	396	84.0			
							46	126	396	84.6			
							48	126	396	85.2			
							52	126	396	86.0			
							57	124	389	87.1			
							60	123	385	87.8			
101-HC	1280	1350	1420	1530	1700	1810	53	152	398	86.0	3810	0.28	4.8
							56	152	398	86.5			
							59	152	398	87.0			
							64	152	398	87.7			
							70	149	391	88.7			
101-GB	1400	1480	1560	1680	1870	1990	81	148	387	89.2	2100	0.21	4.1
							59	166	400	87.2			
							62	166	400	87.6			
							65	166	400	88.1			
							70	166	400	88.7			
							77	163	393	89.6			
							94	162	389	90.0			
101-FC	1830	1720	1810	1940	2170	2300	69	192	402	88.2	4500	0.16	3.1
							72	192	402	88.7			
							76	192	402	89.1			
							82	192	402	89.6			
							90	189	395	90.4			
							94	187	391	90.6			
101-EB	1840	1930	2040	2200	2470	2620	75	207	387	89.0	1950	0.13	2.5
							79	207	387	89.4	1950		
							79	198	370	89.9	2040		
							79	184	343	90.6	2200		
							79	164	306	91.3	2470		
							79	154	287	91.8	2620		
101-DC	2220	2340	2480	2630	2930	3110	88	245	384	90.2	4500	0.1	1.7
							94	245	384	90.5			
							99	245	384	90.8			
							106	245	384	91.2			
							116	241	377	91.9			
							122	238	373	92.1			

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Question 2

A conveyor belt system with constant load torque uses a three-phase induction motor driven by a variable speed drive with V/f control. V/f ratio is maintained up to 50 Hz. The motor name plate is shown below.

ABB							
CE		IE3		IEC60034-1			
3- Motor		M2BAX 280SMC 4 IMB3/IM1001					2014
3026614-1							
No. 3G1P144001206						Ins. cl. F IP 55	
V	Hz	kW	r/min	A	cos φ	Duty	
690 Y	50	90	1485	92	0.86	S1	
400 D	50	90	1485	159	0.86	S1	
660 Y	50	90	1483	96	0.87	S1	
380 D	50	90	1483	166	0.87	S1	
440 D	60	90	1785	144	0.86	S1	
460 D	60	90	1786	139	0.85	S1	
IE3-50Hz-95.2(100%)-95.6(75%)-95.5(50%) / IE3-60Hz-95.4(100%)							
Product code 3GBA282230-ADM							
6217/C3  6217/C3							
621 kg							

- a) Explain what it is meant by Insulation class F and Duty S1. [6 marks]
- b) Sketch the motor terminal and show the connection of the supply cables to the motor terminals. Supply voltage is 400V, 50 Hz. [3 marks]
- c) Calculate the voltage when motor supply frequency is 40 Hz (the speed torque curves are parallel for all frequencies below 50 Hz) and deliver constant load torque 250 Nm. The motor parameters are given below.

$$R_s = 0.02 \, \Omega, R_r' = 0.03 \, \Omega, X_s = 1.8 \, \Omega, X_r' = 0.8 \, \Omega$$

Continued...

Given torque equation as:

$$T = \frac{3}{\omega_{ms}} \left[\frac{V^2 R'_r / s}{\left(R_s + \frac{R'_r}{s} \right)^2 + (X_s + X'_r)^2} \right]$$

[12 marks]

- d) Calculate the mechanical power motor delivered in (c) and electrical power used by the motor is the load is approximately 50%.

[4 marks]

Continued...

Question 3

Six dust collectors are connected to one exhaust fan shown in Figures Q3a and Q3b. The exhaust fan is driven by a 3-phase induction motor. A star-delta starter is used for the motor. The motor has been operating for 11 years.

Motor Name plate information

37kW, 415V, 66.6 A, 4 pole, 1465 rpm, efficiency 91%, IE1.

Electrical Parameters measured at the start delta starter when motor runs.

400V, 60A, pf 0.83

Damper is used to control the flow rate.

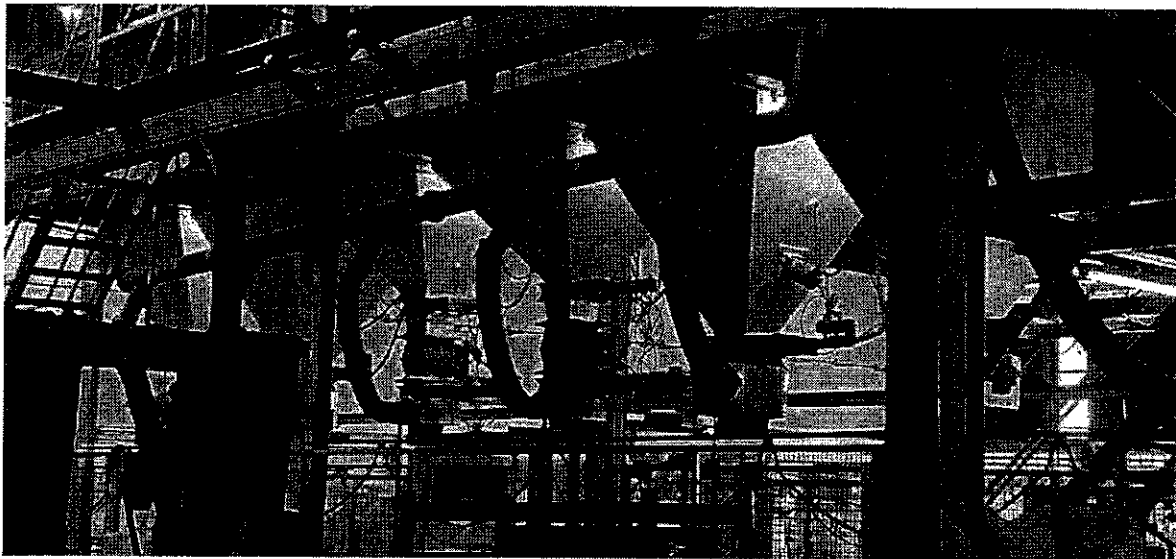


Figure Q3a : Dust Collector System

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Figure Q3b: Exhaust Fan Motor

- a) Calculate the total electrical power consumed by the exhaust system. [2 marks]
- b) Calculate the load factor for the fan system. [2 marks]
- c) What is your technical advice if the plant manager decided to upgrade the system to soft starter as replacement to star-delta starter? [2 marks]
- d) Calculate the total electric energy consumed by the fan in a year. The exhaust motor runs for 24 hours/day, 300 days/year. [2 marks]
- e) Do you feel variable speed drives can reduce energy consumption for the fan system. If yes, give explanation how the upgrade work can be done. Clearly state all assumption (if any) considered during the upgrading work. [11 marks]
- f) Calculate the new electric power for fan system controlled using variable speed drives. The speed of the motor now is 1250 rpm. [2 marks]
- g) Calculate the payback period for the whole upgrading system. The total cost for upgrading work is RM 82,000.00 and average electricity tariff is RM0.50/kWh. [4 marks]

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Question 4

Figure Q4 shows the Vector Controlled PMSM-Drive Operation in an Electric Vehicle.

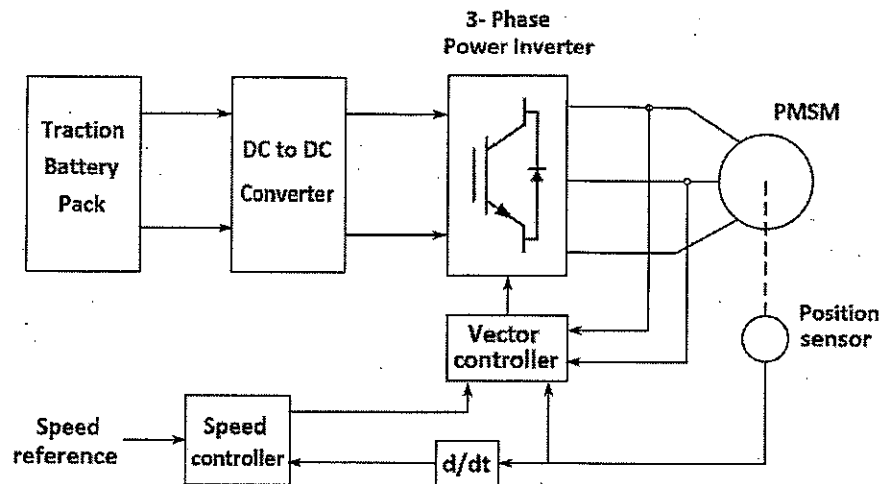


Figure Q4

- With appropriate sketch of rotors, explain two types of PMSM. [6 marks]
- State four advantages of Permanent Magnet Synchronous Motor (PMSM) for electric vehicles. [8 marks]
- Explain the operation of the drive in the electric vehicle especially for speed control. [4 marks]
- Sketch the block diagram for drive system in a typical battery-operated electric vehicle. [4 marks]
- State two challenges in motor drives system in Electric Vehicle. [3 marks]

End of Paper